Spreading of Water Droplets Over Fatty Acid Surfaces

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Spreading process of water droplets over hydrophobic fatty acid surfaces is theoretically considered. The process under investigation is a very slow one and the viscous dissipation in the droplet can be neglected. Fatty acid molecules are supposed to be built by diphilic chains which can rotate in a plane perpendicular to the acid-air interface and are immovable in the tangential direction. Originally diphilic chains are shown to be oriented by hydrophobic tails up. They start a reorientation after a water droplet is placed onto the surface to reduce the water-acid interfacial tension. It is possible to see that a pure reorientation process does not result in the spreading of the water droplet. Indeed, the nearest vicinity of the fatty acid surface outside the droplet remains unchanged in that case and the water edge would meet the originally hydrophobic surface if moves. That means a tangential interaction between neighboring chains (head-head, tail-tail, and head-tail) must be taken into account. A theory is suggested which takes into consideration those interactions. As a result of that interaction hydrophilicity expands in tangential direction even outside the water edge.

A diffusion type equation is derived which describes this transfer. It is supposed that the water edge follows the position on the fatty acid interface where the Young equation is satisfied. It is shown that the spreading process slows down with an increase of the distance between neighboring chains and, as a result, with weakening of the chain-chain interaction (in that case an effective diffusion coefficient of the transfer is decreasing). The theoretical solution of the problem under consideration is considerably simplified if the effective diffusion coefficient is small enough. In that case all transition process takes place in a narrow vicinity of the moving three phase contact line and the matching of asymptotic solutions gives the possibility to reduce the problem to a solution of a single ordinary differential equation which includes only one fitting parameter (timescale).

Comparison with known experimental data shows a reasonable agreement between the theory predictions and experimental results.